

PHOTOMASK

BACUS—The international technical group of SPIE dedicated to the advancement of photomask technology.

Third Place Best Paper Award

Charged Particle Multi-Beam Lithography Evaluations for sub-16nm hp Mask Node Fabrication and Wafer Direct Write

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ABSTRACT

A detailed evaluation study has been performed with respect to the suitability of projection electron and ion multi-beam lithography for the fabrication of leading-edge complex masks. The study includes recent results as obtained with electron and ion multi-beam proof-of-concept systems with 200x reduction projection optics where patterns are generated on substrates using a programmable aperture plate system (APS) with integrated CMOS electronics, generating several thousands of well defined beams in parallel. A comparison of electron and ion projection multi-beam writing is provided, in particular with respect to

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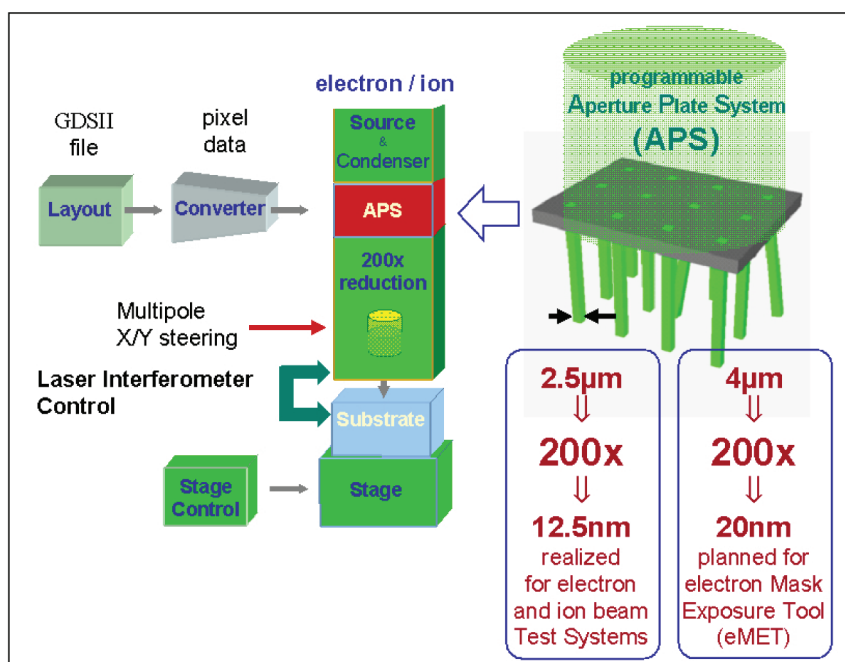


Figure 1. Principles of IMS Nanofabrication charged particle multi-beam techniques.

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EDITORIAL

"Check please!"

Wolfgang Staud, Applied Materials, Inc.

It was just before Thanksgiving 1991. On my way back to Europe I stopped over in Boston to run an interview with a small start-up. Hampshire Instruments, X-Ray Lithography. In school we had heard that nothing would work below 1µm, unless we use X-Ray. And this interview was as close as I thought I'd ever get. It was one of these rare moments when you meet one of the true visionaries – and in this case it was Moshe Lubin. He was one of these charismatic leaders that can completely capture you in their web, and make you believe in achieving the unachievable. Tragically, after having burned some \$100M in the start-up, HI folded, with dire consequences to Moshe [R.I.P.].

Fast forward 2 decades and hundreds of millions of \$s later. We just rang in a new and 3rd one, and all signs at the onset are very positive. In the past 2 decades, we left X-Ray behind, and like many of you I thought that we were done with this subject at least till after we retire. In the meantime the industry embarked on a slightly new adventure, Soft X-Ray. We even gave it a new, less tarnished name: EUV. Alas, over the past decade it consistently stayed the technology that is (at least) one more node in the (near) future.

Could this new decade now really become the 'Age of EUV'?

It all started with a defining strategic meeting hosted by Sematech during Semicon. What at first sounded like the big Dutch Pied Piper's call to join 'the dance of the lemmings*', in the past few month transitioned into a well orchestrated and tightly managed effort to find industry consensus on the #1 roadblock issue: EUV Mask Infrastructure. Source power/stability and resist performance moved down a couple of notches, and mask and blank infrastructure became the focal point of a large array of leading technologists in the industry. The team from Sematech, John Warlaumont and Bryan Rice leading the kick-off meeting, Stefan Wurm and team orchestrating the Technical Working Groups, and Bryan and Mark Sheedy also organizing a Business Working Group, all have done a tremendous job in collecting industry information, requirements, specifications and to a large and surprising degree: consensus!

All of a sudden we all feel a lot wiser and more educated on EUV mask problems. What initially had a touch of a *collective jump over the imaginary cliff associated with it, actually turned into quite a focused decision making process. We all agree on the need to sponsor some very badly needed development programs. Funny enough I see my skeptical self turning around, and accepting the fact that EUV is 'inevitable', and thus in full support of the effort. Less because I am convinced that EUV will be the litho technology for 16nm or even 11nm, but more because the part of the industry that I have chosen to work in – masks – is once again challenged with carrying our collective roadmap.

In the Special Session at BACUS in September we had a highly stimulating discussion among our Panelists and the Audience regarding the needs for infrastructure development – be it for SMO, EUV or NIL. Since this panel discussion, another major event has taken place in the industry, the EUV Symposium in Prague. Follow-

Continues on page 12.

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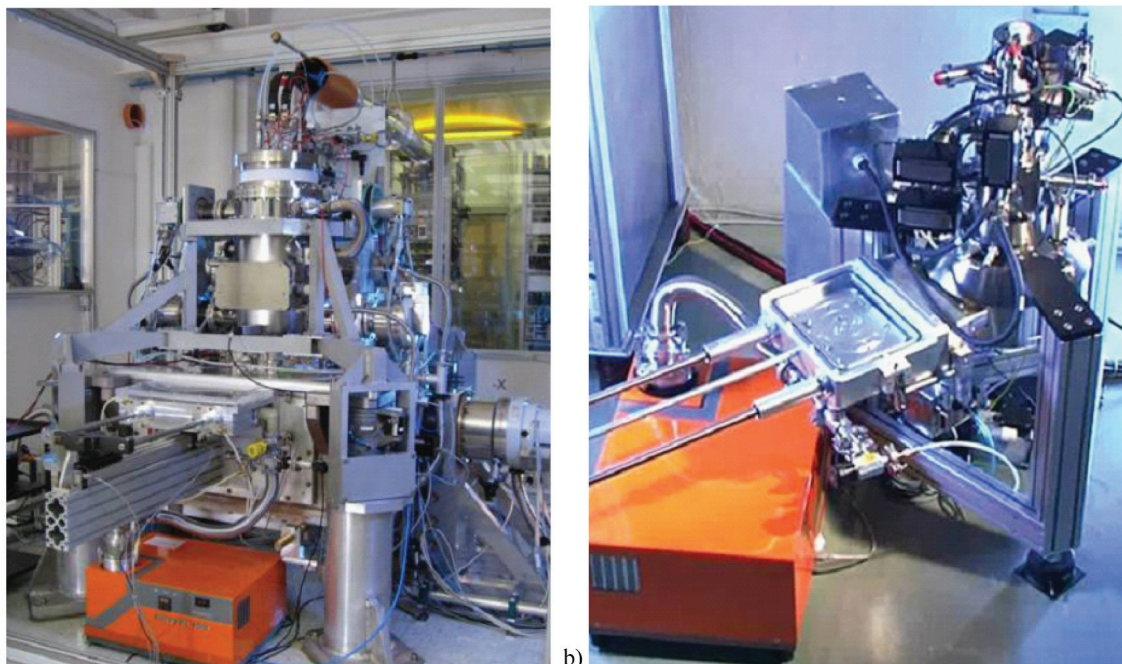


Figure 2. IMS Nanofabrication proof-of-concept test systems for a) Ion multi-beam resist exposure and resistless nanopatterning (CHARPAN Tool), and b) Electron multi-beam resist exposure (PML2 Test System).

the suitability to expose non-chemically amplified resist (non-CAR) materials. The extendibility of projection multi-beam technologies for 16nm hp, 11nm hp and 8nm hp mask nodes is discussed as well as for wafer direct write for 22nm hp and below.

1. Introduction

At recent BACUS and PMJ conferences the use of charged particle multi-beams for the fabrication of leading edge photomasks has been discussed.¹⁻³ In these contributions the concentration was on ion multi-beam lithography and on concepts of an ion Mask Exposure Tool (iMET). Recently the study was widened to include electron multi-beam lithography. The present contribution provides the status of this comparative study of ion vs. electron multi-beam lithography for mask fabrication and the prospects for a multi-generational electron Mask Exposure Tool (eMET). Furthermore, the potential of 50 keV e-beam based projection maskless lithography (PML2) for wafer direct write⁴ is outlined.

2. Projection Multi-Beam Technology with 200x Reduction

The principles of the IMS Nanofabrication charged particle multi-beam techniques are shown in Figure 1. A broad charged particle beam is directed to a programmable Aperture Plate System (APS) forming thousands of micrometer sized beams which are demagnified to the substrate with 200x reduction. The APS consists of an Aperture Plate shaping the micrometer sized beamlets and – in proximity – a Blanking Plate with integrated CMOS electronics. The openings in the Blanking Plate are larger compared to the openings in the Aperture Plate.

Thus, the beams are transmitted through the Blanking Plate. Adjacent to the openings in the Blanking Plate are ground and deflection electrodes. Powering a deflection electrode with the CMOS electronics a slight change of beam direction is induced. The slightly deflected beams are filtered out near the 2nd cross-over of the charged particle projection optics. Thus, only the beams which are unaffected by the Blanking Plate are projected to the substrate with 200x reduction. In the realized electron and ion multi-beam test systems programmable beams of 12.5nm have been generated. For the electron Mask Exposure Tool (eMET) a beam size of 20 nm is planned (Figure 1).

3. Ion Multi-Beam Test System Exposures with 43k-APS Unit

The ion multi-beam test system (called CHARPAN Tool) was equipped in Feb 2009 with a first 43k-APS unit. CHARPAN Tool 43k-APS exposures were done on 150mm Si wafers and 6" mask blanks. The 43k-APS unit consists of an Aperture Plates with 43,008 openings of 2.5µm x 2.5µm size and 30µm periodicity and a Blanking Plate with integrated 0.25µm CMOS electronics with openings of 7µm x 7µm size unit (Figure 3a). The electroplated ground and deflection electrodes have a height of 32µm (Figure 3b). Using this 43k-APS unit 43-thousand programmable beams of 12.5nm size are generated within an exposure field of ca. 25µm x 25µm (Figure 3c).

The 43k-APS unit had more than 99% yield with respect to blanker functionality. Thus, there are several "always-on" and "always-off" beam defects leading to corresponding exposure failures at the substrate (Figure 4a). Adopting proprietary 16x

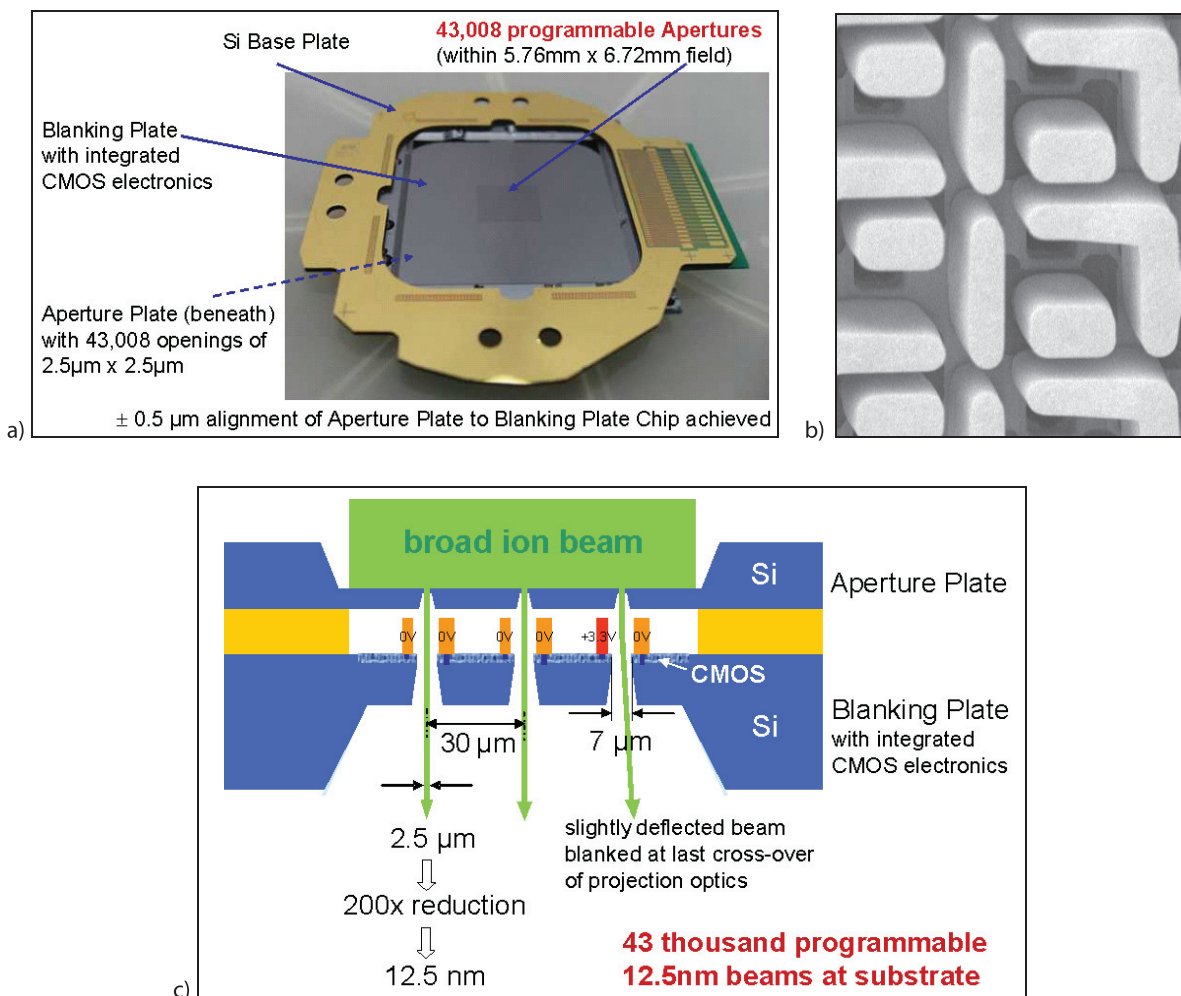


Figure 3. 43k-APS unit for the ion multi-beam CHARPAN Tool; a) photo, b) SEM of electroplated Au ground and deflection electrodes of 32µm height adjacent to 7µm x 7µm openings through 35µm Si Blanking Plate membrane, c) side view schematics.

redundancy exposure mode techniques virtually perfect imaging is obtained as demonstrated in Figure 4b.

For resolution test exposures a GDSII file⁵ was transferred into pixel data which were fed to the 43k-APS in the CHARPAN Tool. Figure 5a shows part of a resolution test patterns within a 20µm x 20µm exposure field exposed with 10 keV H₃⁺ ions in 50nm HSQ non-chemically amplified negative resist on 150mm Si wafer. The exposure dose was as low as 12 µC/cm² due to the fact that the Hydrogen particles transmitted through the resist are generating a large number of low energy (~ eV) electrons leading to efficient interaction. Figure 5b shows a detail of the 60nm, 30nm, 20nm and 10nm 1:2 resolution patterns. Figure 5c and Figure 5d show 1:1 and 1:2 patterns in 20 nm HSQ resist, resolving the 20 nm pattern in both cases. The resist exposure dose was not dependent on the resist thickness. Figure 6a shows a logic test pattern with 40 nm hp minimum feature size, Figure 6b iso-lines down to 20 nm line width.

For more details on exposures done with the CHARPAN Tool with integrated 43k-APS on HSQ coated 6" OMOG mask

blanks see Ref. [3].

Implementing gray scaling and redundancy exposure techniques the line width was varied in very fine steps. Figure 7a shows lines of different widths between 95.0 and 132.5 nm, changed in steps of $37.5/16 \approx 2.34$ nm. The exposure was done in 40 nm HSQ resist on 6" OMOG mask blank. Further processing³ and CD-SEM (Vistec LWM90xx) evaluations were done at ims chips. Figure 7b shows lines etched into 60 nm MoSi and corresponding LER analysis.

The width of 25µm long lines was measured with the CD-SEM 26 times (1µm distance between the measurement points) for the evaluation of CD uniformity. The line width measurement values in the 25µm x 25µm exposure field were found to be within ± 1.1 nm (Figure 7c).

The CHARPAN Tool exposures were done so far with coarse stage positioning, connecting the substrate to the ionoptical column during exposure. In the meantime a laser-interferometer controlled stage has been realized by Delong Instruments (Brno, Czech Republic) which has been incorporated and

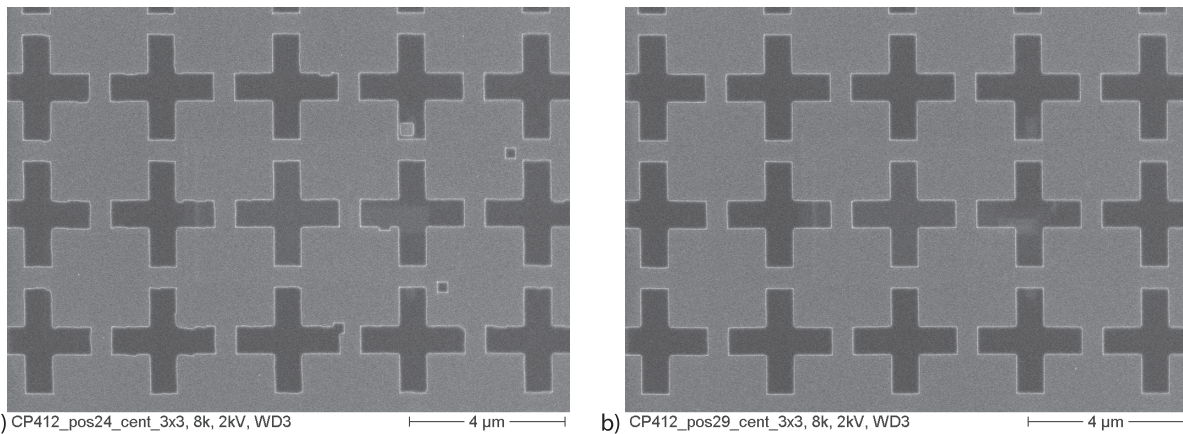


Figure 4. CHARPAN Tool 43k-APS exposure of cross patterns in 50 nm HSQ resist, a) exposure without redundancy showing the influence of “always-on” and “always-off” APS beam defects; b) exposure with 16x redundancy (from the same position within the 20 μm x 20 μm exposure field), in both cases exposure with 10 keV H^+ ions with 20 μC/cm² dose.

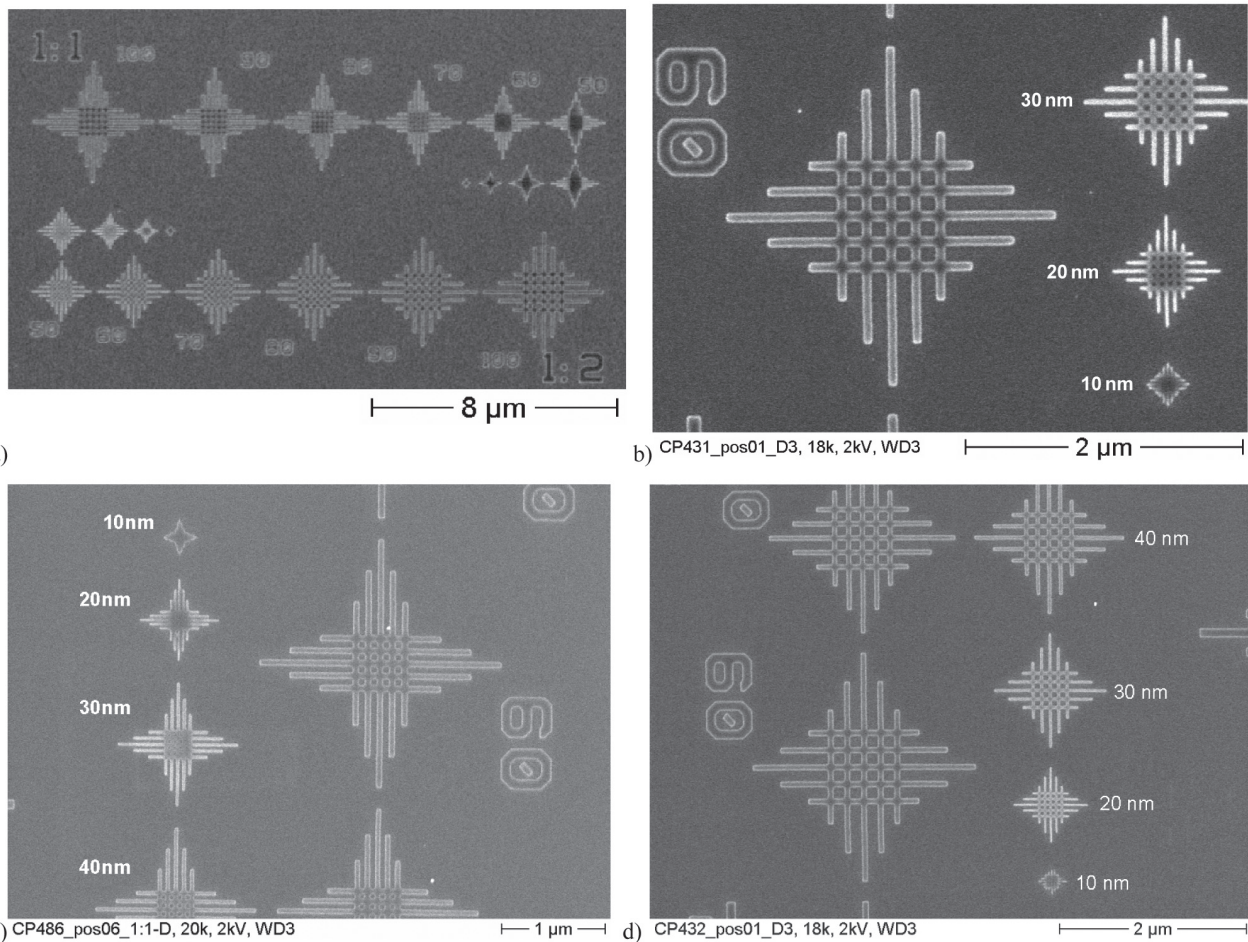


Figure 5. CHARPAN Tool 43k-APS exposure (with 16x redundancy) of cross patterns in HSQ negative resist on Si wafer, a) part of 20 μm x 20 μm exposure field (design: [5]) with 1:1 and 1:2 resolution test patterns; b) detailed view of 1:2 patterns as exposed in 50 nm HSQ, c) detailed view of 1:1 patterns in 20 nm HSQ, d) detailed view of 1:2 patterns in 20 nm HSQ. The 10 keV H_3^+ exposure dose was 12 μC/cm² in all cases.

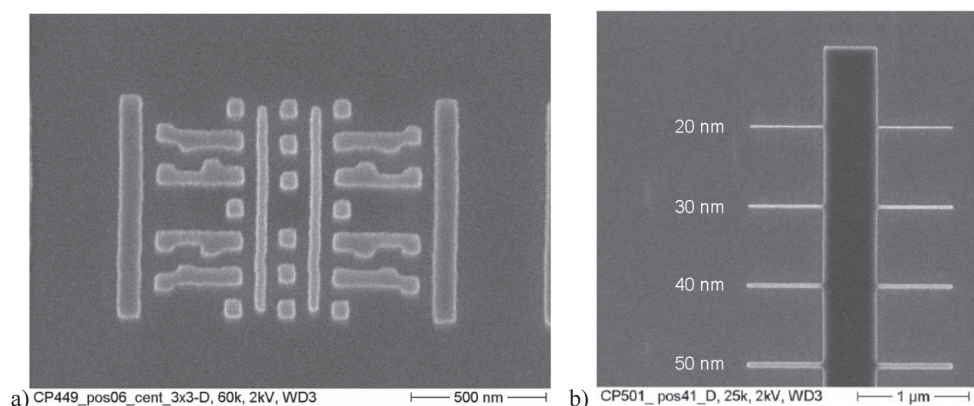


Figure 6. CHARPAN Tool 43k-APS exposure (with 16x redundancy) with 10 keV H_3^+ ions in 40 nm HSQ non-chemically amplified resist on Si wafer with $12 \mu\text{C}/\text{cm}^2$ exposure dose of a) 40 nm logic pattern and b) iso-line pattern.

Table 1. eMET – 50 keV e-beam optics specifications.

Electron beam energy at substrate	50 keV
Exposure field of projection e-beam optics	82μm x 82μm
Number of programmable beams	512 x 512 (= 262 144)
Beam size at substrate	20nm x 20nm
Current per beam	4pA
Max. e-beam current at substrate	1μA
beam blur (FWHM) @ 1μA current through column	8.5nm
Minimum feature size for Lines & Spaces / Single Lines	32nm / 22nm

tested successfully under vacuum conditions in a new tool platform (Figure 8a). The existing ion-optical column with demonstrated 12.5 nm hp resolution capability using 10 keV ions (Figure 10, Figure) will be integrated onto this new set-up in order to demonstrate ion projection multi-beam 43k-APS exposures on a scanning stage (Figure 8b).

Enhancing the beam energy to 20 keV a resolution below 10 nm hp will be achievable (Figure 9). This will be of benefit for the development of a CHARPAN master template writer for nanoimprint lithography (NIL). There will also be the integration of a precursor gas injection system to realize 3D ion multi-beam assisted etching and deposition,^{6,7} completing the CHARPAN Nanopatterning Tool.

When inducing a multipole shift in only one direction 12.5nm hp lines were obtained; at lower dose the line width is below 10 nm (Figure 12a) but the pattern suffers from adhesion problems which vanish at higher dose (Figure 12b). Figure 12c and Figure 12d show 12.5nm hp dot exposures; again at lower dose sub-10nm diameter dots are resolved but many fall over; enhancing the dose the HSQ dots are widened providing

enough adhesion to the Si substrate.

4. Electron Multi-Beam Test System Exposures with 43k-APS Unit

The schematics of the realized projection electron multi-beam test system are shown in Figure 13. As indicated, recently a 43k-APS unit was inserted to this column. In the condenser e-beam optics of the test system the beam diameter is limited to 2 mm. Consequently only a fraction of the 43k-APS area was illuminated, with 200x reduction realizing 2500 programmable 12.5nm beams within an exposure field of $7.5\mu\text{m} \times 7.5\mu\text{m}$. The beam energy at the substrate can be varied between 15 keV and 50 keV which is of advantage to study Coulomb interaction effects. Using a movable 150mm/300mm wafer chuck several exposure fields can be placed on a substrate. Non-chemically amplified resist materials are used for proof-of-concept experiments: positive ZEP520A and negative HSQ.⁴

Examples of first exposures with the 2500 programmable

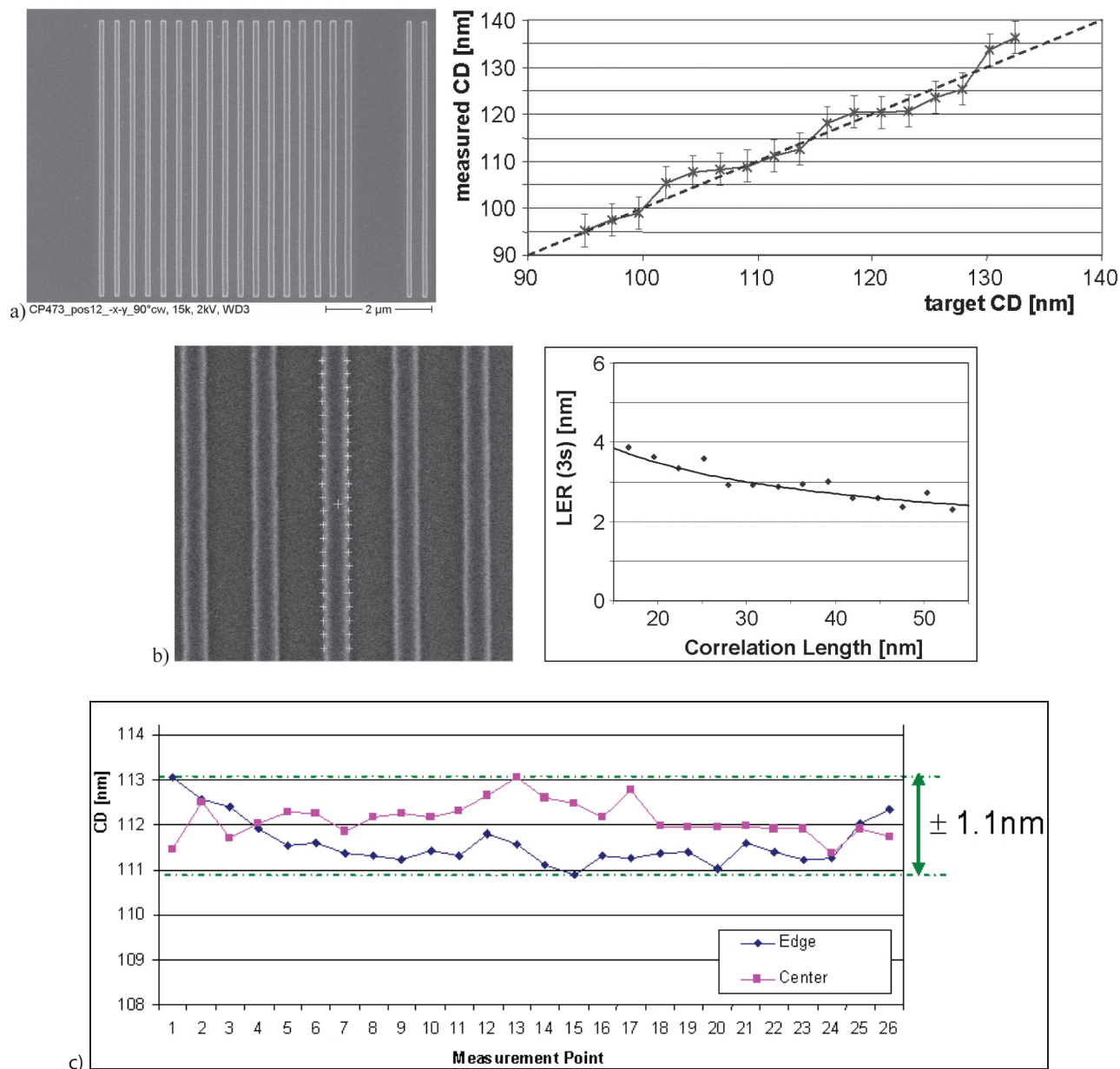


Figure 7. CHARPAN Tool 43k-APS exposure (with 16x redundancy) with 10 keV H_3^+ ions, a) lines of 25μm length and width varied in 2.34 nm steps between 95.00 nm and 132.50 nm exposed in 40 nm HSQ on 6" OMOG mask blank, subsequent pattern transfer into 15nm Cr hard mask and 60nm MoSi on quartz; b) CD-SEM of etched lines in 60nm MoSi on quartz of ca. 112nm width and 300nm periodicity taken after hard mask removal together with line edge roughness (LER) analysis, and c) CD-SEM measurement results of line width uniformity of etched 60nm MoSi lines of ca. 112 nm width, 300 nm periodicity and 25μm length at center and edge of a 20μm x 20μm exposure field [3].

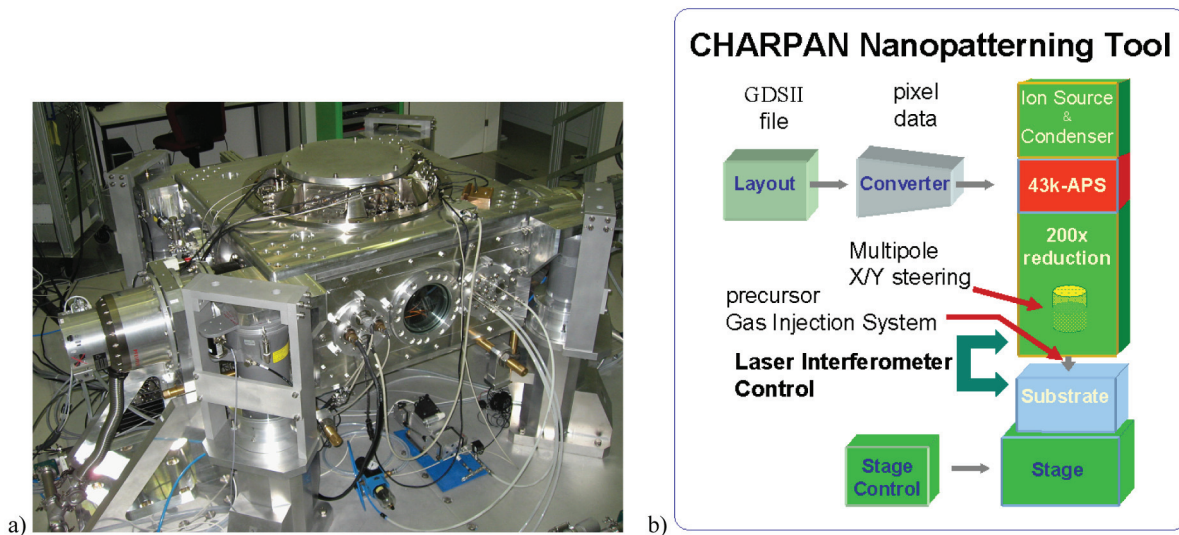


Figure 8. a) New tool platform with integrated laser-interferometer controlled vacuum stage with vacuum lock (for up to 6" mask blank substrate size), realized for the CHARPAN 3D Nanopatterning Tool (b).

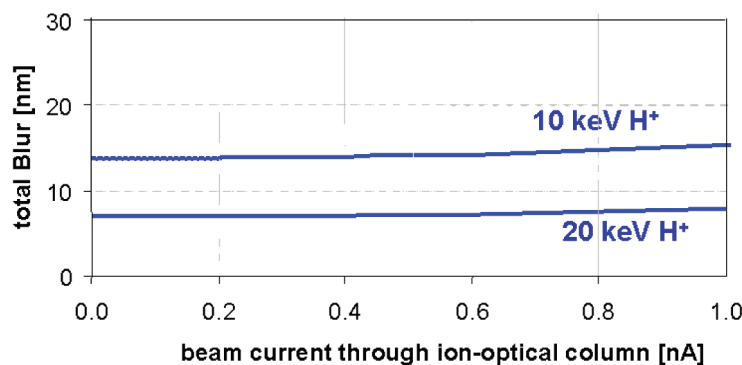


Figure 9. Simulated resolution (total blur FWHM) vs. ion beam current through CHARPAN ion-optical column.

electron beams of 12.5nm spot size exposed in 50nm HSQ resist are shown in Figure 14, demonstrating the electron projection multi-beam exposure principles.

5. Electron Mask Exposure Tool (eMET)

At SPIE Photomask BACUS 2008 the concept and prospects of an ion Mask Exposure Tool (iMET) were presented. In 2009 IMS Nanofabrication studied the potential of a 50 keV electron beam based Mask Exposure Tool (eMET), which provides the following benefits:

- The mask industry is familiar of using e-beam based tools for mask writing,
- The eMET projection e-beam optics can be more readily integrated with existing mask writer tool platforms,
- Suitable resist materials are available for 50 keV e-beam exposure (including positive and negative non-chemically amplified resists),
- The multi-generational eMET may be extended to the 8nm hp mask technology node.

Consequently IMS Nanofabrication concentrates efforts on the realization of a 50 keV electron Mask Exposure Tool (eMET). The target specifications of the eMET column are listed in Table 1. Implementing a "256k-APS", the number of programmable beams will be enhanced to more than 250 thousand. The eMET column will be capable to generate 32nm hp lines as needed for the 8nm hp mask technology node.

At SPIE Photomask BACUS 2008 the potential throughput of the ion Mask Exposure Tool (iMET) was presented.² The mask writing time without overheads equals the mask area to be exposed times the resist exposure dose and divided by the total multi-beam current. For a mask area of 104mm x 132mm (26mm x 33mm die with 4x reduction) the anticipated iMET writing time is 8.5 hours. For the electron Mask Exposure Tool (eMET) the same writing time can be obtained when using a resist with 220 $\mu\text{C}/\text{cm}^2$ exposure dose as a beam current as large as 1 μA is feasible. When using a resist exposure dose of less than 125 $\mu\text{C}/\text{cm}^2$ mask writing times of less than 5 hours may be obtained for leading-edge complex masks (Figure 15).

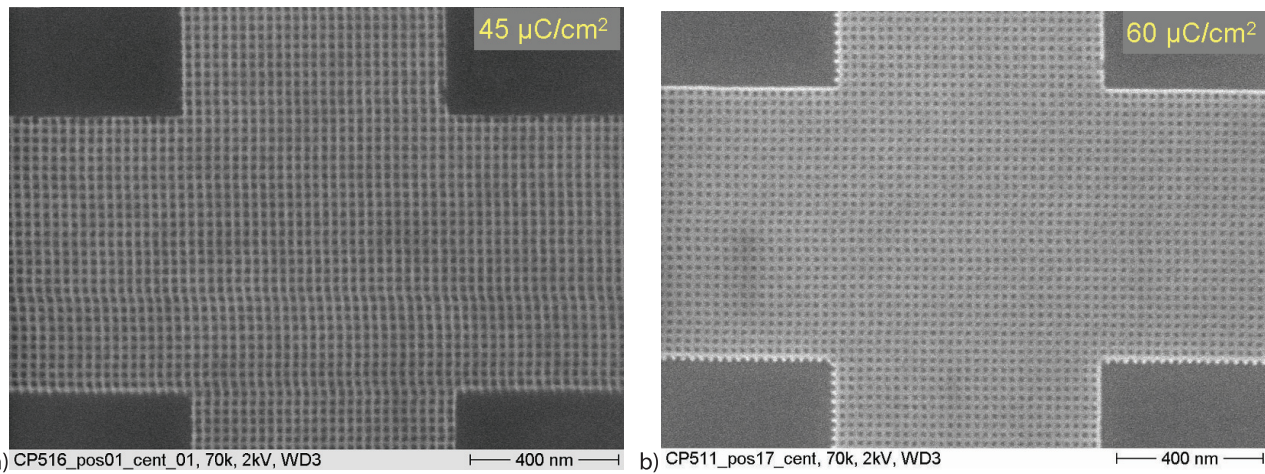


Figure 10. Results of CHARPAN Tool resolution study using an aperture plate providing 8.3 nm beams with 25 nm periodicity. Exposure of 20 nm thick HSQ resist on Si with development in NaOH/NaCl leading to an enhancement of exposure dose [8]: a) exposure of cross-lines with 45 $\mu\text{C}/\text{cm}^2$ exposure dose; b) overexposure with 60 $\mu\text{C}/\text{cm}^2$ (explanation see Figure 11).

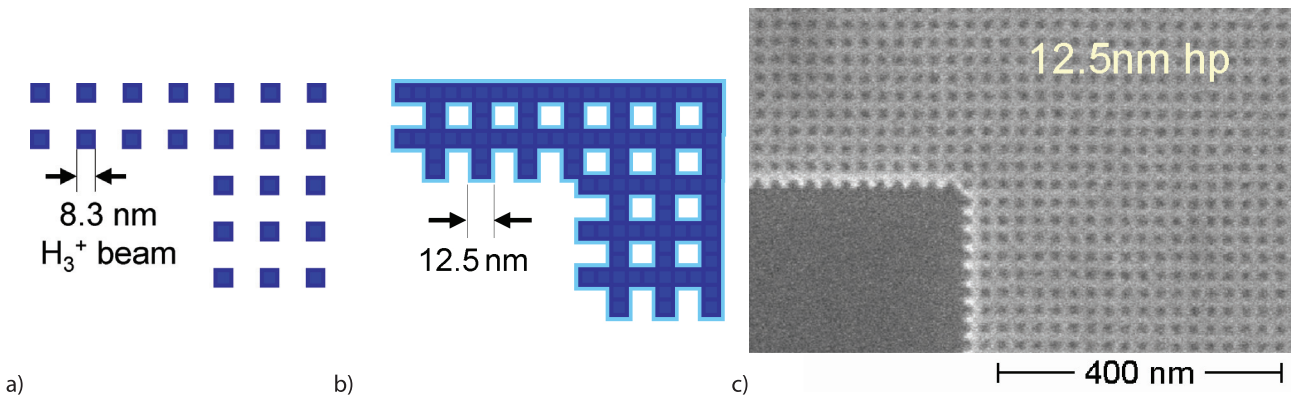


Figure 11. CHARPAN Tool resolution experiment; a) 8.3 nm beams with 25 nm periodicity as provided with 200x reduction projection of $1.67\mu\text{m} \times 1.67\mu\text{m}$ apertures, b) Schematics of step exposure induced by electrostatic multipole X/Y shifts of the ion beamlets; line widening to 12.5 nm due to overexposure, c) Result of corresponding exposure in 20 nm HSQ resist on Si with 10 keV H_3^+ ion multi-beams (detail of Figure 10c) demonstrating 12.5 nm hp resolution capability.

6. 50 keV E-Beam Projection Maskless Lithography (PML2)

The application fields of the IMS Nanofabrication electron and ion multi-beam techniques are outlined in Figure 16.

Using the eMET electron-optical column IMS Nanofabrication is planning to realize a PML2 Prototype Tool by:

- implementing a platform with a 300mm wafer stage,
- modifying the 256k-APS by using an Aperture Plate with $2.4\mu\text{m} \times 2.4\mu\text{m}$ opening size, generating 256-thousand programmable 12 nm sized 50 keV electron beams at the 300mm wafer substrate.

7. Conclusion

The proof-of-concept of the IMS Nanofabrication projection multi-beam technology has been demonstrated for ion as well as for electron beams. Ion multi-beam projection techniques are of interest for the fabrication of master templates and 3D

nanopatterning. With respect to mask fabrication further efforts are concentrated on realizing a 50 keV electron Mask Exposure Tool (eMET) providing 256-thousand programmable beams. The eMET column is multi-generational down to the 8nm hp mask technology node. The electron multi-beam projection techniques may be applied for 50 keV electron projection maskless lithography (PML2).

8. Acknowledgments

This work was supported by the European Commission through funding of the projects CHARPAN (charpan.com), RIMANA (rimana.org) and MAGIC (magic-fp7.eu) Gray scale exposure data preparation was done with the "Layout Beamer" software from GenISys.

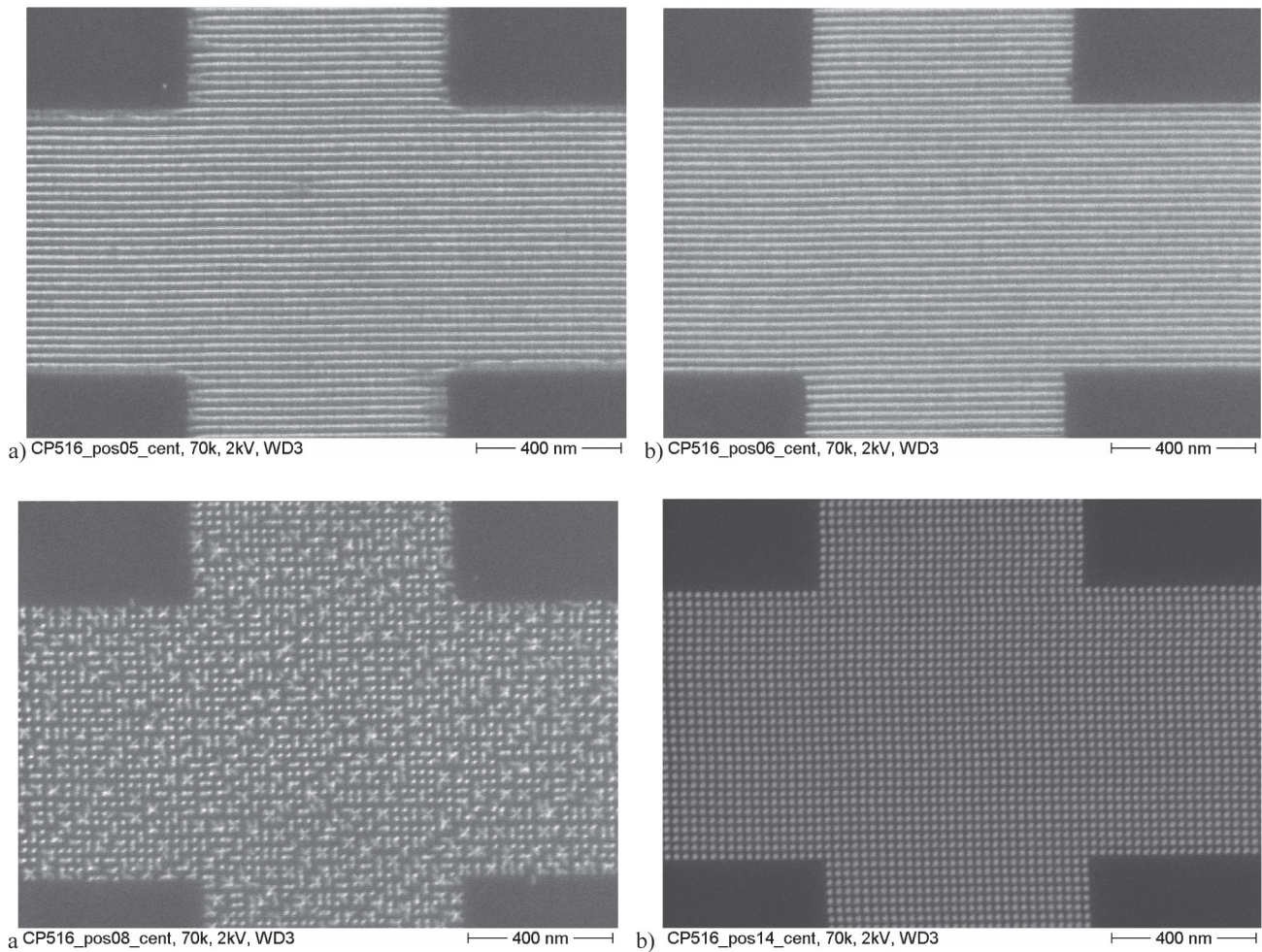


Figure 12. CHARPAN Tool resolution experiment using 10 keV H_3^+ 8.3nm beams with 25 nm periodicity as provided with 200x reduction projection of $1.67\mu\text{m} \times 1.67\mu\text{m}$ apertures. Exposure of 20nm HSQ resist on 150mm Si wafer; resist development in NaOH/NaCL, leading to enhanced exposure dose [8]: a) 12.5nm hp lines, exposure dose: $65 \mu\text{C}/\text{cm}^2$, b) 12.5nm hp lines, exposure dose: $71.5 \mu\text{C}/\text{cm}^2$; c) 12.5nm hp dots, exposure dose: $160 \mu\text{C}/\text{cm}^2$, d) 12.5nm hp dots, exposure dose: $320 \mu\text{C}/\text{cm}^2$.

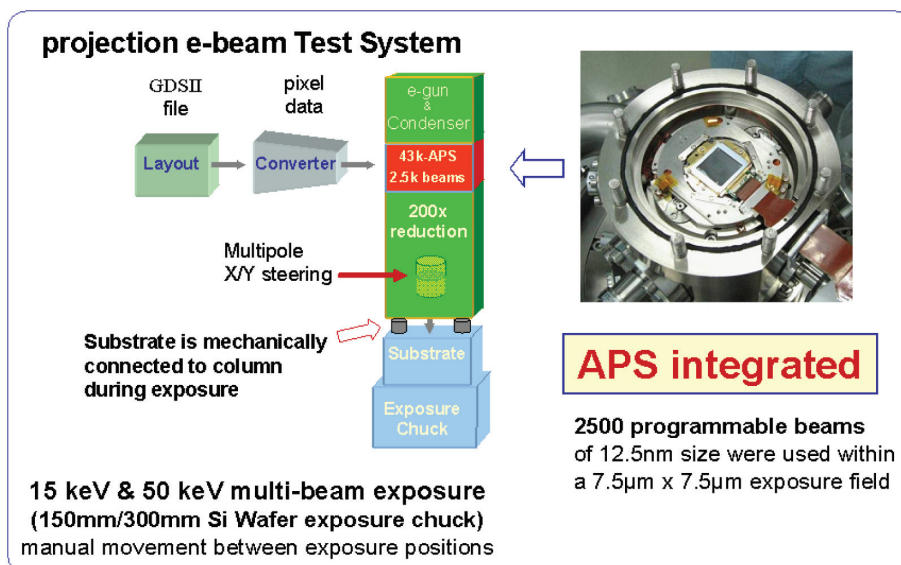


Figure 13. Schematics of Projection electron multi-beam Test System and photo of integrated 43k-APS unit.

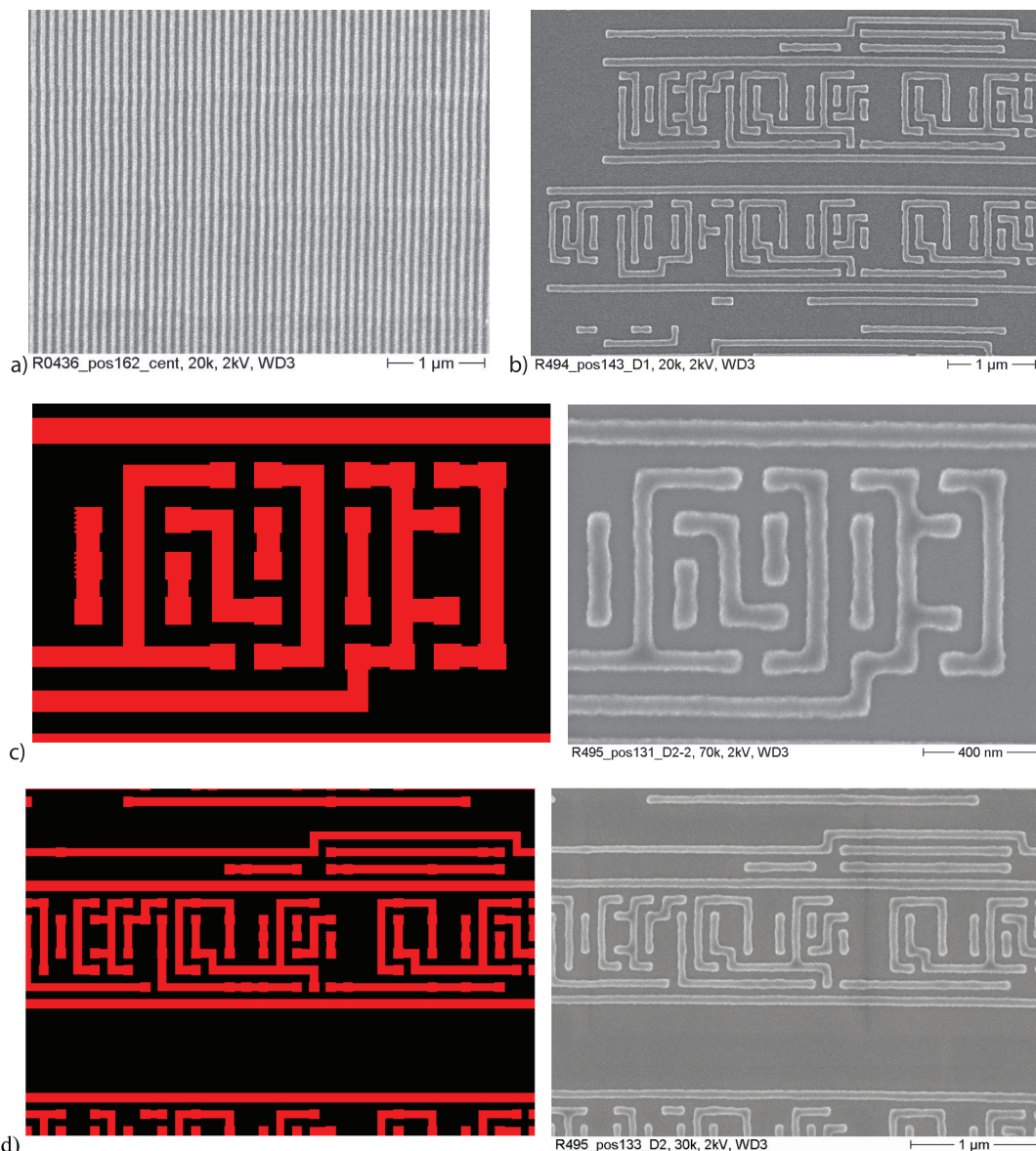


Figure 14. Projection electron multi/beam Test System exposure in 50nm HSQ negative resist using 2500 programmable 12.5nm electron beams of 15 keV energy, a) 45nm hp line pattern, b) 75nm hp, c) data input and 75 nm hp exposure result, and d) data input and 65nm hp exposure.

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iMET (BACUS 2008)			eMET			eMET	
Current:	90 nA	↔	Current:	1 μ A	↔	Current:	1 μ A
Dose:	20 μ C/cm ²		Dose:	220 μ C/cm ²		Dose:	< 125 μ C/cm ²
Writing time:	8.5h		Writing time:	8.5h		Writing time:	< 5h

Figure 15. iMET and eMET mask writing time for a mask area of 104mm x 132mm (100% pattern coverage).

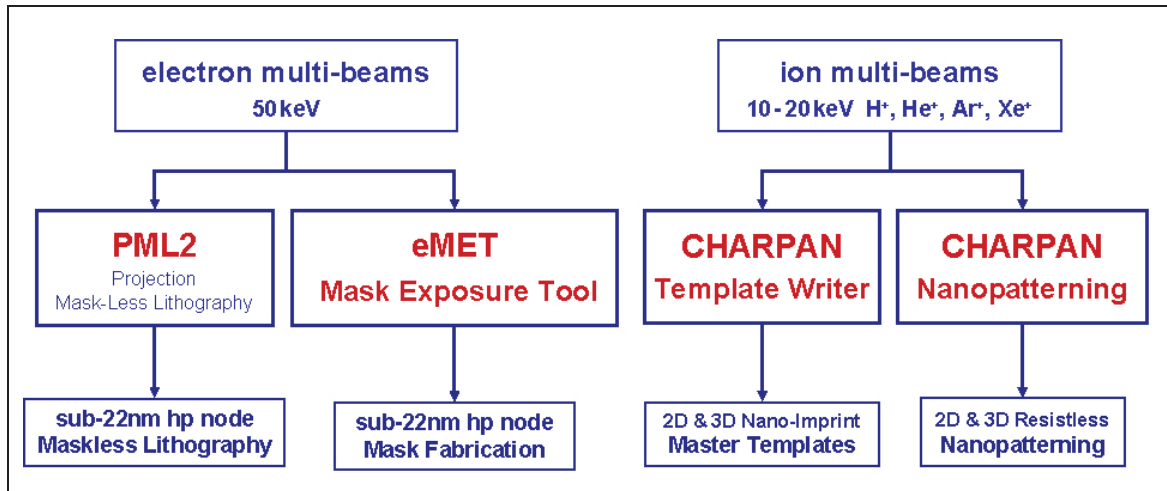


Figure 16. Application fields of IMS Nanofabrication technology.

EDITORIAL (continued from page 2)

ing that symposium Sematech, based on feedback from members and participants in their TGW and BWG, has taken one major redirection in their approach, and is now considering OBI, Optical Blank Inspection, as a important first step in improving EUV mask blank quality. While this segment is now deviating from the original triple-a road-map, actinic blank, actinic AIMS and actinic patterned mask inspection, it promises to yield a much earlier and quicker ramp in mask quality. Blank inspection routines are achievable by the major 19Xnm inspection platforms currently available, and systems could be deployed as early as Q210.

Which brings me to the overarching question of this editorial. For SPIE's Advanced Lithography 2010 in San Jose end February, the BACUS team is once again staging a major panel discussion for conference attendees

on Monday eve. And the topic follows the theme given in Monterey: "EUV Source \$10M. EUV Scanner \$100M. Defect Free EUV Photomask, Priceless! For some there's NIL, for everyone else, there's EUV".

Leading authorities from the field are invited to discuss the *push into a viable mask infrastructure. Captive semiconductor companies appear willing to invest in the development of wafer processing equipment, but are shunning investments in mask equipment. And merchant mask makers and blank suppliers see a windfall of EUV development only in years to come, so for now they do not directly support this *push either.

During the Panel we will be serving cocktails again – at least to the folks on stage. But when we are done with all the discussions, the remaining question that will need to be answered, for the cocktails and mask infrastructure alike, is: "Who's gonna pick up the tab??".

Industry Briefs



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■ The Struggle to Fund the Completion of EUV Continues

Interviews with key executives by Semiconductor International reveal cautious optimism along with significant challenges remaining. Regarding the funding of mask tools for EUV production, Franklin Kalk, Executive Vice President and CTO, Toppan Photomasks Inc. says while production-worthy EUV lithography is years away, events in the first half of 2010 will determine the timing, and perhaps the extent, of EUV's displacement of 193 nm. The outcome depends on the cost of creating the infrastructure for EUV photomasks. Three key mask tools are needed: inspection tools for mask blanks and patterned masks, and an aerial-image microscope (AIMS) tool to verify that finished masks print the desired image. The problem: amortizing the cost to create them over the small number of EUV masks needed in the five to seven years following the investment. The pattern inspection tool has a large enough market that cost should be within range of current systems. The AIMS tool is more challenging. Assuming the total available market is ~10 machines and non-recurring engineering costs are >\$60M, per-tool NRE is higher than the entire cost of a 193 nm AIMS tool. The biggest challenge is blank inspection. The two potential producers of EUV mask blanks would each need one tool with NRE of ~\$25M per tool. Combined with low mask-blank volume, this would result in an order-of-magnitude cost increase for EUV mask blanks over ArF. This risky model has forced the industry to consider alternatives like collective financing of development, re-jiggering traditional mask production flows and the suggestion that merchant maskmakers share a single EUV production line. Meeting EUV's proposed 2013 production insertion requires funding in the first half of 2010. Sematech is seeking to shepherd the various players into a workable model; its ability to accomplish this will be critical to EUV's reaching market.

■ HamaTech is Acquired By SUSS MicroTec

SUSS MicroTec AG announced the conclusion of contract negotiations to acquire HamaTech APE GmbH & Co. KG, a wholly owned subsidiary of Singulus Technologies AG, for a purchase price of EUR 4.5 million plus a further EUR 4.5 million for the acquisition of the land and company building at the Sternenfels site. The closing date of the transaction is set for January 2010.

HamaTech APE has established itself in the semiconductor industry as a leading global supplier of equipment for cleaning photo masks. It employs approximately 80 staff at its Sternenfels site and its international subsidiaries. In the 2009 fiscal year, the Company is expected to generate sales of EUR 11 million.

With the acquisition, the SUSS MicroTec Group is expanding its existing Coater/Developer product portfolio. "HamaTech APE's 20 years of experience in developing processes and equipment along with its highly innovative cleaning technology ideally complement SUSS MicroTec's core competency of critical wet processing in semiconductor production," commented Frank Averdung, Chief Executive Officer of SUSS MicroTec AG. "The modern production site at Sternenfels is ideally suited for expansion into a group-wide competence center for "wet processing". We therefore intend to relocate the Coater and Developer production set up in neighboring Vaihingen to the Sternenfels plant," Frank Averdung continued.

"The high performance and efficiency of our systems have turned us into the globally recognized market leader in our sector. We address the most demanding requirements of 193i conventional lithography and, in addition, we are today the only supplier of solutions for cleaning masks for EUV (extreme ultraviolet) lithography," Wilma Koolen-Hermkens, Managing Director of HamaTech APE, remarked. "We look forward to being able to offer our extensive expertise to our customers as part of the SUSS MicroTec Group in the future."

Join the premier professional organization for mask makers and mask users!

About the BACUS Group

Founded in 1980 by a group of chrome blank users wanting a single voice to interact with suppliers, BACUS has grown to become the largest and most widely known forum for the exchange of technical information of interest to photomask and reticle makers. BACUS joined SPIE in January of 1991 to expand the exchange of information with mask makers around the world.

The group sponsors an informative monthly meeting and newsletter, BACUS News. The BACUS annual Photomask Technology Symposium covers photomask technology, photomask processes, lithography, materials and resists, phase shift masks, inspection and repair, metrology, and quality and manufacturing management.

Individual Membership Benefits include:

- Subscription to BACUS News (monthly)
- Complimentary Subscription *Semiconductor International* magazine
- Eligibility to hold office on BACUS Steering Committee

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Corporate Membership Benefits include:

- One Voting Member in the SPIE General Membership
- Subscription to BACUS News (monthly)
- One online SPIE Journal Subscription
- Listed as a Corporate Member in the BACUS Monthly Newsletter

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C a l e n d a r

2010



SPIE Advanced Lithography

21-26 February
San Jose Marriott and
San Jose Convention Center
San Jose, California, USA
spie.org/al



SPIE Photomask Technology

13-17 September
Monterey Marriott and
Monterey Conference Center
Monterey, California, USA
spie.org/pm

*Abstract submissions will open
early January.*



SPIE Lithography Asia - Korea

Fall 2010
Location and Dates TBD - check
<http://spie.org/la/> for updates.



Photomask Japan

13-15 April
Yokohama, Japan
<http://www.photomask-japan.org/>

Abstracts Due 15 March 2010.

You are invited to submit events of interest for this calendar. Please send to lindad@spie.org; alternatively, email or fax to SPIE.

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